UNCLASSIFIED

AD NUMBER
AD860848
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies only; Administrative/Operational Use; SEP 1969. Other requests shall be referred to Commanding Officer, Naval Ship Research and Development Laboratory, Annapolis, MD 21402.
AUTHORITY
DWTNSRDC ltr, 4 Aug 1978

THIS PAGE IS UNCLASSIFIED

MATLAB 373

Proposed Revision of Military Specification MIL-S-24201(SHIPS) Sewage Treatment Equipment Chlorinator-Macerator for Naval Shipboard Use

AD 860848

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER

Washington, D.C. 20007

NAVAL SHIP RESEARCH AND DEVELOPMENT LABORATORY
Annapolis, Maryland 21402

PROPOSED REVISION OF MILITARY SPECIFICATION MIL-S-24201(SHIPS) SEWAGE TREATMENT EQUIPMENT CHLORINATOR-MACERATOR FOR NAVAL SHIPBOARD USE

By
D. J. Fisk and H. H. Singerman

Each transmittal of this document outside the agencies of the U. S. Government must have prior approval of Commanding Officer, Naval Ship Research and Development Laboratory, Annapolis, Maryland 21402

MATERIALS LABORATORY
SPECIFICATION DEVELOPMENT

September 1969

MATLAB 373

26

The Naval Ship Research and Development Center is a U.S. Navy center for laboratory effort directed at achieving improved sea and air vehicles. It was formed in March 1967 by merging the David Taylor Model Basin at Carderock, Maryland and the Marine Engineering Laboratory at Annapolis, Maryland. The Mine Defense Laboratory, Panama City, Florida, became part of the Center in November 1967.

Naval Ship Research and Development Center
Washington, D.C. 20007

NDW-NSRDC 3960/46 (10-67)

PROPOSED REVISION OF MILITARY SPECIFICATION MIL-S-24201(SHIPS)
SEWAGE TREATMENT EQUIPMENT CHLORINATOR-MACERATOR FOR
NAVAL SHIPBOARD USE

By
D. J. Fisk and H. H. Singerman

September 1969

MATLAB 373

ABSTRACT

A statistical evaluation of a variety of sewage treatment methods indicates that MIL-S-24201(SHIPS) should be revised with respect to performance requirements for the reduction of coliform most probable number density counts made after chlorination treatment of sanitary wastes. Such a proposed revision of the specification is given in this report which also indicates the coliform density for large samples of either untreated or treated sewage tends to follow a lognormal frequency distribution.

ADMINISTRATIVE INFORMATION

The evaluation was performed at this activity during Fiscal Years 1967, 1968, and 1969 under Task Area S-F35 433 006, Task 1892. This report meets Fiscal Year 1970, Milestone 3, as described on page 154 of the May 1969 NAVSHIPRANDLAB, Annapolis, Program Summary. The work was done under Assignment 823-121-32.

TABLE OF CONTENTS

NAVAL SHIP RESEARCH AND DEVELOPMENT LABORATORY

PROPOSED REVISION OF MILITARY SPECIFICATION MIL-S-24201(SHIPS) SEWAGE TREATMENT EQUIPMENT CHLORINATOR-MACERATOR FOR NAVAL SHIPBOARD USE

By
D. J. Fisk and H. H. Singerman

INTRODUCTION

Extensive evaluations and a comprehensive statistical study of a variety of treatment methods, as used in two different types of naval shipboard chlorinator-macerator sewage treatment systems, have been made. They indicate that Military Specification MIL-S-24201(SHIPS) should be revised with respect to performance requirements for the reduction of coliform most probable number (MPN) density counts after chlorination treatment of sanitary wastes.

In addition to the revised performance requirements, the report of this work also shows that coliform density counts for large samples of either treated or untreated sewage tend to follow a lognormal frequency distribution.

The present chlorination acceptance sampling performance requirements, as given in MIL-S-24201(SHIPS), are based on an expected complete coliform kill probability (zero coliform MPN count) for each of ten sample runs tested. A more realistic concept might be to specify that any strength chlorination treatment used will cause a certain proportion, P_K, of test runs to produce sample MPN counts no greater than some nominally specified MPN_K count, i. e., $P_C(MPN \leq MPN_K) = P_K$.

This limiting MPN_K count would be chosen on the basis of information available from real test data. Also, any approved chlorination treatment should be such that the user must be reasonably confident that the use of some restricted amount of chlorine solution will result in a very high reduction (99+%) of the treated sample run coliform (MPN) density counts over what the presumed MPN count would be if the sanitary wastes were not treated.

BACKGROUND CONDITIONS FOR REVISION OF MIL-S-24201(SHIPS)

Figure 1 shows coliform (MPN) density counts obtained for a series of chlorination injection treatments of sanitary wastes at various disinfectant strengths (including no treatment at all) using two different MIL-S-24201(SHIPS) type chlorinator-macerator machines (A and B). Sample $\log_{10}$MPN values were plotted versus cumulative probability, P_i, on normal probability paper. (Zero MPN counts were assigned a nominal value of one.) As illustrated in Figure 2, using the $\log_{10}$MPN coliform density counts of untreated waste plotted in Figure 1, a large number of coliform (MPN) density measurements taken under the same or similar treatment conditions will approximate a lognormal distribution pattern (i.e., the logarithms of the measurements will be normally distributed). Thus, sample means and standard deviations ($\bar{X}_L$ and S_L) can be used to determine estimated (computed) probability values (P_C) associated with various $\log_{10}$MPN (see Appendix A).

This has been done in Table 1 for the treatment data plotted in Figure 1. The antilogs of the computed $\log_{10}$MPN parameters, shown in Lines 1 and 3, are used to compute the 50% (median or geometric mean) and 90% probability values shown in Lines 4 and 5. As a further indication of lognormality, 50% (or 90%) of the MPN counts in a sample of runs might be expected to be below the lognormal computed value ($c_{50(90)}$) for a specified treatment condition. This is actually the case, as shown in Table 1 (Line 6), for the 90% probability level, since at least 90% of the sample MPN counts are below the 90% computed probability point (c_{90}), for all the given treatment conditions. The bottom lines of Table 1 (Line 7) are used to show the probability that an MPN count will approximate zero or be no greater than 240 or 1000 for each treatment condition. This may be read directly from Figure 1, since $P_C(\log_{10}\text{MPN} \leq \log_{10}\text{MPN}_K)$ is the equivalent of $P_C(\text{MPN} \leq \text{MPN}_K)$. Since $\bar{X}_L$ is the $\log_{10}$MPN equivalent of the c_{50} (or 50%) MPN probability value and $\bar{X}_L + 1.28\ S_L$ is the $\log_{10}$MPN equivalent of the c_{90}(or 90%) MPN probability value, these probability points have been plotted in Figure 3 to establish regression equations, at 50% and 90% probability, for chlorine injection treatment requirements *versus* estimated $\log_{10}$MPN counts.

Table 1
Some Distribution Parameters and Probability Points For
Coliform (MPN) Density Counts From Sanitary Wastes
Using Two Macerator-Chlorinator
Sewage Treatment Machines (A and B)

	Machine A [1]				Machine B [1]				Machine A & B Comb-ination	
N (Sample Size)=	Un-treated	270+360 [a] ml*	450+540 [a] ml	1000 ml	Un-treated	300 ml	500 ml	700 ml	Un-treated	Line
	50	70	60	24	30	60	60	10	80	
X_L=Log MPN										
$\bar{X}_L$ =	7.6305	2.1421	1.6426	0.8533	7.4034	2.6390	1.8378	0.7349	7.5433	1
S_L =	0.5561	1.8054	1.7261	1.2140	0.9877	1.9[illegible]	2.0054	1.5846	0.7498	2
$\bar{X}_L+1.28S_L$ =	8.3423	4.4530	3.8520	2.4072	8.6677	5.1560	4.4047	2.7632	8.5030	3
MPN										
c_{50} =	4.271 x10[illegible]	139	44	7	2.532 x10[illegible]	437	[illegible]	5	3.494 x10[illegible]	4
c_{90} =	2.199 x10[illegible]	2.838 x10[illegible]	7112	255	4.653 x10[illegible]	1.432 x10[illegible]	2.5[illegible] x10[illegible]	530	3.184 x10[illegible]	5
$P_t(MPN_t \le c_{90})$ =	90%	90%	90%	92%	90%	90%	90%	90%	90%	6
(N_t/N)	(45/50)	(63/70)	(54/60)	(22/24)	(27/30)	(54/60)	([illegible]/60)	([illegible]/10)	(72/80)	
P_c(MPN>1000) =	<1%	63%	78%	30%	<1%	[illegible]	72%	62%	<1%	7
P_c(MPN≤240) =	<1%	55%	66%	90%	<1%	46%	[illegible]	80%	<1%	
P_c(MPN=0) =	<1%	12%	17%	24%	<1%	9%	19%	32%	<1%	

[1] Liquid solution used, per flush, contains 10% chlorine by weight.
[a] Coliform MPN counts derived from two different injection treatments have been combined into one distribution of MPN counts.

Note: c_{50} (Median or Geometric Mean) = Antilog $(\bar{X}_L)$, where $P_c(MPN \le c_{50})$ = 50%

c_{90} = Antilog $(\bar{X}_L + 1.28S_L)$, where $P_c(MPN \le c_{90})$ = 90%

$\bar{X}_L = \frac{\Sigma X}{N}$, $S_L = \sqrt{\frac{N\Sigma X^2 - (\Sigma X)^2}{N(N-1)}}$, $P_c(MPN \le 1000) = P_c(\log MPN \le 3.0)$,

$(X = X_L)$ $P_c(MPN \le 240) = P_c(\log MPN \le 2.38)$

$P_c(MPN = 1) = P_c(\log MPN = 0)$

$P_t(MPN_t \le c_{90})$ is the proportion (N_t/N) of tabulated MPN counts that are less than or equal to some computed 90% probability value, c_{90}. (Note that all treatment $P_t(MPN_t \le c_{90}) \ge 90\%$).

*Abbreviations used in this text are from the GPO Style Manual, 1967, unless otherwise noted.

A further examination of Figures 1 and 3 and of Table 1 indicates that there is a proportionate reduction in coliform (MPN) density counts for the chlorinated over the unchlorinated sanitary wastes, up to some maximum injection treatment (i.e., between 300 and 500 ml per flush, at the 90% probability level). This treatment, in most cases, should bring the coliform (MPN) density count down to approximately the same order of magnitude ($10^3 \leq MPN \leq 10^6$). However, to reach some specified low MPN coliform count (e.g., $MPN \leq 1000$ (or 240) for P_c = 90%), approximately the same chlorination treatment strength would be required, regardless of the original coliform (MPN) density, as long as the expected coliform (MPN) density for untreated sanitary wastes approaches some minimum order of magnitude (e.g., $MPN \leq 10^7$ for P_c = 90%).

APPROACH

ALTERNATIVE TREATMENT CONDITIONS FOR THE REVISION OF MIL-S-24201 (SHIPS)

From the curves in Figure 3 (extrapolating where necessary), it is estimated that the following minimum chlorination injections per flush would be required to reduce expected coliform (MPN) density counts to counts no greater than 240 or 1000 for 50% (or 90%) of the sample runs as compared to the chlorination injections required to obtain an expected (approximate) zero MPN count for 50% (or 90%) of the sample runs. If coliform (MPN) density counts obtained from samples of untreated sanitary wastes are compared to a proposed maximum MPN count of 0, 240, or 1000, the reduction ratios (percent decrease in coliform MPN counts) listed in Table 2 can be estimated for Machines A and B at the 50% and 90% probability levels.

For these specified injection treatments

$$P_c(MPN \leq 1000) \equiv P_c(\log_{10} MPN \leq 3.00) = 50\%(90\%)$$

$$P_c(MPN \leq 240) \equiv P_c(\log_{10} MPN \leq 2.38) = 50\%(90\%)$$

$$P_c(MPN = 1) \equiv P_c(\log_{10} MPN = 0) = 50\%(90\%) .$$

Table 2
Reduction Ratios at Selected Probability Levels

Specified MPN_K	Machine Used	No Treatment: 50% Probability Level A: $c_{50} = 4.271 \times 10^7$ B: $c_{50} = 2.532 \times 10^7$ IT (per flush), ml	RR_{50} %	90% Probability Level A: $c_{90} = 2.199 \times 10^8$ B: $c_{90} = 4.653 \times 10^8$ IT (per flush), ml	RR_{90} %
1000	A	210	99.9977	800	99.9995
	B	260	99.9960	670	99.9998
240	A	270	99.9994	1000	99.9999-
	B	400	99.9991	740	99.9999+
≈0	A	1450	≈100	1825	≈100
	B	810	≈100	930	≈100

IT - Injection Treatment

K = 50(90)

$$RR_{50(90)} = \left(\frac{c_{50(90)} - MPN_K}{c_{50(90)}}\right)100,$$

the Reduction Ratio (percent expected decrease in coliform (MPN) density counts) at the 50% and 90% probability levels for a chlorination injection treatment resulting in an $MPN \leq MPN_K$, as compared to expected coliform (MPN) density counts (c_{50}, c_{90}) obtained from untreated sanitary wastes.

It should be noted that there is no particular confidence assigned to the injection treatment requirements for the specified probabilities (P_c) shown in Table 2. However, since the sample standard deviation (S_L) of coliform $\log_{10}$MPN counts on which these requirements are based is assumed to be an average measurement for a comparatively small sample of measurements selected from a population or very large number of similar measurements, these requirements are assumed to be related to the 50% confidence level only.

The statistical method* shown below may be used for estimating the value of a population standard deviation (σ_L) based on the sample standard deviation (S_L), the number (N) of sample measurements, and the well known (Chi-squared) statistical parameter $\chi^2_{CL, N-1}$, where CL is the proportion of sample standard deviations of N measurements each, derived from a population (very large number) of $\log_{10}$MPN counts, which are expected to be less than or equal to some specified value

$$\sigma_L \leq \frac{S_L}{(\chi^2_{CL, N-1}/N-1)^{1/2}} \cdot$$

Therefore, the population parameter, σ_L, may, for example, be used in place of S_L in estimating probability limits (P_c = 90%) and associated probability points (c_{90}) with increased confidence (CL) that P_c and c_{90} are the true measurement parameters (e.g., $\log_{10} c_{90} = \overline{X}_L + 1.28\sigma_L$). The computed MPN count c_{90} is the coliform count associated with $P_c(\text{MPN} \leq 1000) = 90\%$, sample size N, and some specified confidence (CL), where CL = 1 - α. Here, α is defined as the risk that an equipment might be accepted when less than 90% of all the MPN counts in a population of counts are below a specified c_{90} value.

The above procedure will be used to assure a reasonable degree of confidence in the results of the specified acceptance sampling criteria, as developed in this report.

OPERATING CONDITIONS REQUIRED TO MEET DESIRABLE PERFORMANCE SPECIFICATIONS

As indicated in Table 2, an excessive amount of chlorine solution would most likely be required in a MIL-S-24201(SHIPS) type chlorinator-macerator sewage treatment equipment to reduce the expected coliform (MPN) density count to zero for even 90% of the sample runs, under most conditions of operation. A practical as well as statistically valid approach would be to select appropriate acceptance criteria from one of the nominal coliform (MPN) density values greater than zero, presented in Table 2.

*Juvinal, Robert C., Stress, Strain, and Strength, New York, McGraw Hill Book Co., Sec. 17.9, 1967, p. 356

Table 2 indicates that, on the average, based on empirical test data results from two different MIL-S-24201(SHIPS) type chlorinator-macerators, an injection treatment of 700 to 800 ml per flush of chlorine solution containing 10% available chlorine by weight should (for 90% of the sample runs) be able to reduce the expected coliform (MPN) density of raw macerated sanitary waste from a magnitude of 10^7 to 10^8 (or less)/100 ml to 1000 (or less)/100 ml. Such a chlorine injection treatment would also result in a reduction ratio (percent decrease in coliform (MPN) density of treated over untreated sanitary wastes) of over 99.99%.

However, increasing the proposed chlorine injection treatment above the 700 to 800 ml average requirements will, of course, increase the degree of confidence the test operator has that at least 90% of the coliform MPN counts in a population of runs will not exceed some specified maximum coliform MPN count. Figure 4 shows such lower confidence bands (50% to 95%) for the estimated coliform MPN counts (expressed as $\log_{10}$MPN) associated with various chlorine injection rates when $P_c(\text{MPN} \le 1000) = 90\%$.

Table 3 lists the estimated chlorine injection rates required in order to produce the indicated confidence (CL) that at least 90% of the coliform MPN counts in a population of runs will have an MPN≤1000.

Table 3
Chlorine Injection Required Per Flush
For $P_c(\text{MPN} \le 1000) = 90\%$

Confidence Level, %	Machine A, ml	Machine B, ml
50	800	685
60	825	700
70	850	715
80	875	740
90	925	815
95	970	950

Thus, if an 850 ml injection per flush is used under the same operating conditions, Machine A indicates with 70% confidence and Machine B with over 90% confidence that at least 90% of the coliform MPN counts in a population of runs will have an MPN≤1000 (i.e., $P_c(\text{MPN} \le 1000) = 90\%$). This may be contrasted to an 800 ml injection which, used in Machine A, would assure with just 50% confidence, and used in Machine B with between 80% and 90% confidence, that $P_c(\text{MPN} \le 1000) = 90\%$.

In order to show, with the same degree of confidence, that at least 90% of the coliform MPN counts in a population of runs would approximate a zero count (i.e., $P_c(MPN \simeq 0) = 90\%$) the following comparable chlorine injections would be necessary (see Table 4).

Table 4
Injection Treatment Requirements

Confidence Level, %	$P_c(MPN \leq 1000) = 90\%$, ml	$P_c(MPN \simeq 0) = 90\%$, ml
	Machine A	
50	800	1490
70	850	1540
	Machine B	
80	740	900
90	815	1100
95	950	1400

Thus, for example, 1540 ml chlorine injection would be required in Machine A (with 70% confidence) and between 1100 and 1400 ml in Machine B (with over 90% confidence) to assure an approximate zero MPN count for 90% of the runs in a population of runs. This may be compared to an 850 ml injection required to assure with equivalent confidence (70% for Machine A and over 90% for Machine B) an MPN count no greater than 1000, for 90% of the runs in a population.

ACCEPTANCE CRITERIA

ESTABLISHMENT OF ACCEPTANCE CRITERIA FOR MEETING PERFORMANCE SPECIFICATIONS FOR A MIL-S-24201(SHIPS) TYPE CHLORINATOR-MACERATOR SEWAGE TREATMENT EQUIPMENT

The following factors should be considered in establishing an appropriate performance criteria:

- Program test results should be based on a sufficiently large number of possible test runs over a sufficient number of days (e.g., 10 runs per day, up to 10 days) so as to minimize sampling errors due to changes in day-to-day and run-to-run operating conditions.

- A lower limit for the number of test runs required for acceptance purposes could be established, on the basis of MIL-S-24201(SHIPS) requirement of a zero MPN (confirmed) count for some specified number of consecutive runs. The assumption might be made that if a MIL-S-24201(SHIPS) type chlorinator-macerator sewage treatment equipment can be developed that would guarantee 100% kill probability for the specified number of consecutive runs, assuming the use of a reasonable amount of chlorine solution, further testing would be unnecessary, and testing could then be terminated with the acceptance of the equipment.

- Since there is a time lag of up to 3 days between test performance and test results, the test operator might or might not wish to delay making further runs until after the results of the first day's testing have been determined.

A description of such a proposed sampling program, to determine acceptable performance for a MIL-S-24201(SHIPS) type chlorinator-macerator sewage treatment is given below. Also presented are proposed operating restrictions concerning chlorine solutions used, calendar time required to complete a test program, and the coliform (MPN) density reduction requirements for treated sanitary wastes as compared to untreated sanitary wastes.

PROPOSED PERFORMANCE CRITERIA FOR A MIL-S-24201(SHIPS) TYPE CHLORINATOR-MACERATOR SEWAGE TREATMENT EQUIPMENT

It is proposed that the equipment be operated for 10 consecutive runs per day beginning at the peak morning period for a maximum of 10 days under the conditions described below, over a time interval not to exceed 3 weeks, with weekend sampling excluded. Samples from each run will be obtained for bacteriological examination by the procedures described in paragraph 4.2.2 of MIL-S-24201(SHIPS), as amended 16 August 1966 (with appropriate restrictions on sampling methods and the maximum strength to be used for chlorination treatments), and the coliform MPN (confirmed) present in each run will be determined.

At the completion of 100 runs, if no more than a cumulative total of 10 runs show an MPN (confirmed) greater than 1000, it is proposed that the equipment be accepted as meeting performance test requirements. If more than 10 such runs occur, it is proposed that the equipment be rejected.

PROPOSED RESTRICTIONS ON PERFORMANCE REQUIREMENTS FOR TESTING OF MIL-S-24201(SHIPS) TYPE CHLORINATOR-MACERATOR SEWAGE TREATMENT EQUIPMENTS

It is proposed that the following restrictions apply when developing a sampling program for testing the performance of MIL-S-24201(SHIPS) type chlorinator-macerator sewage treatment equipments, based on the reduction of coliform (MPN) density in sanitary wastes.

- The chlorination injection treatment used must result in a coliform (MPN) density no greater than 1000/100 ml for at least 90% of the runs in a sample.

- The required chlorination injection treatment must not exceed an 850 ml liquid solution (containing 10% chlorine by weight) per flush.

- Acceptance testing for the performance of an equipment must be completed over a time interval not to exceed 3 weeks.

- The chlorination treatment used must be able to reduce an expected coliform (MPN) density for untreated sanitary wastes of up to 10^7/100 ml for 90% of sample runs, to a coliform (MPN) density no greater than 1000/100 ml for 90% of sample runs.

Item (a) - Machine A

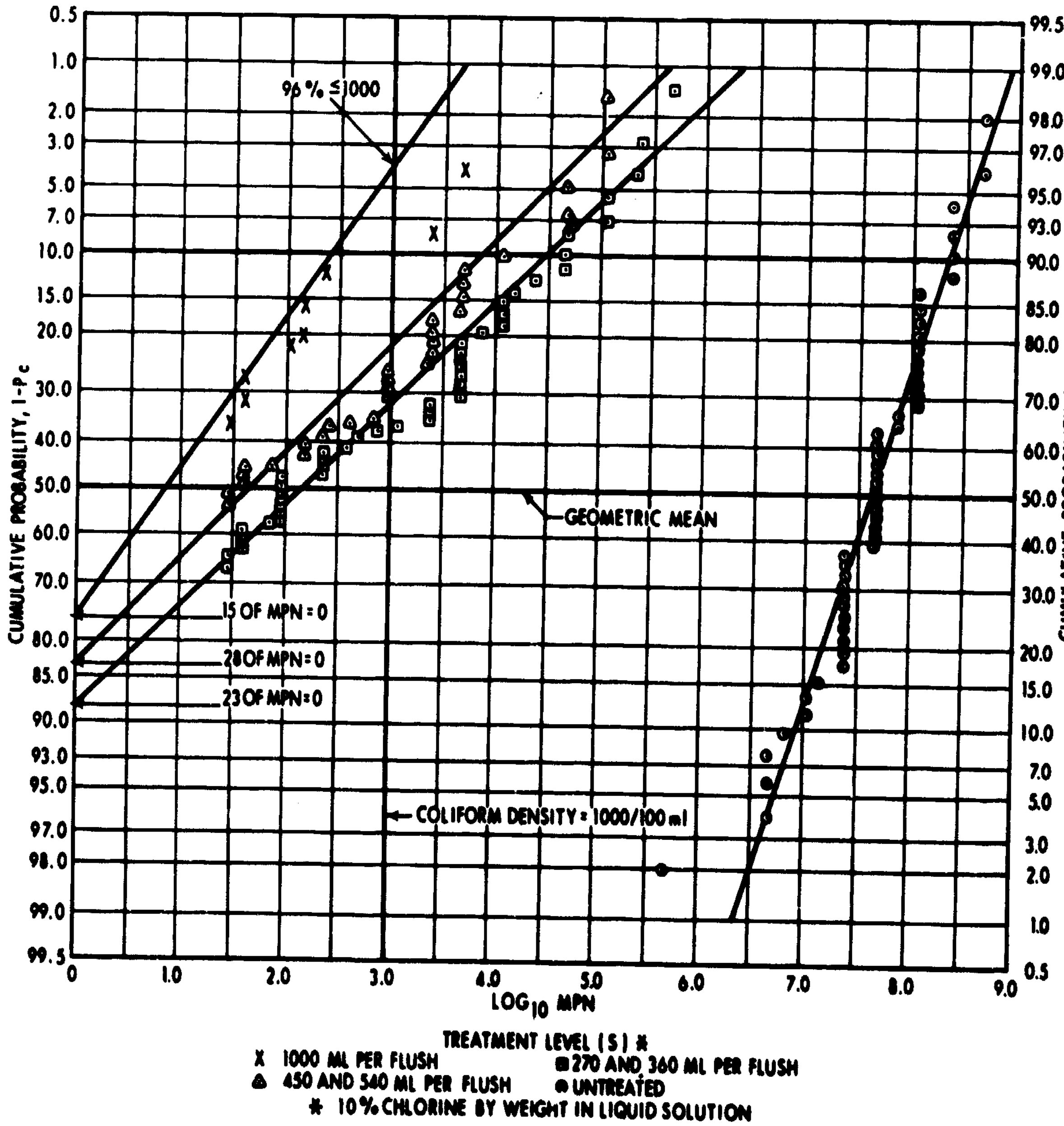


Figure 1 - Estimated Percent Probability, P_c, That Sample Coliform MPN's Will Be No Greater Than Computed MPN's, With Coliform Kill A Function of Treatment Level

Item (b) - Machine B

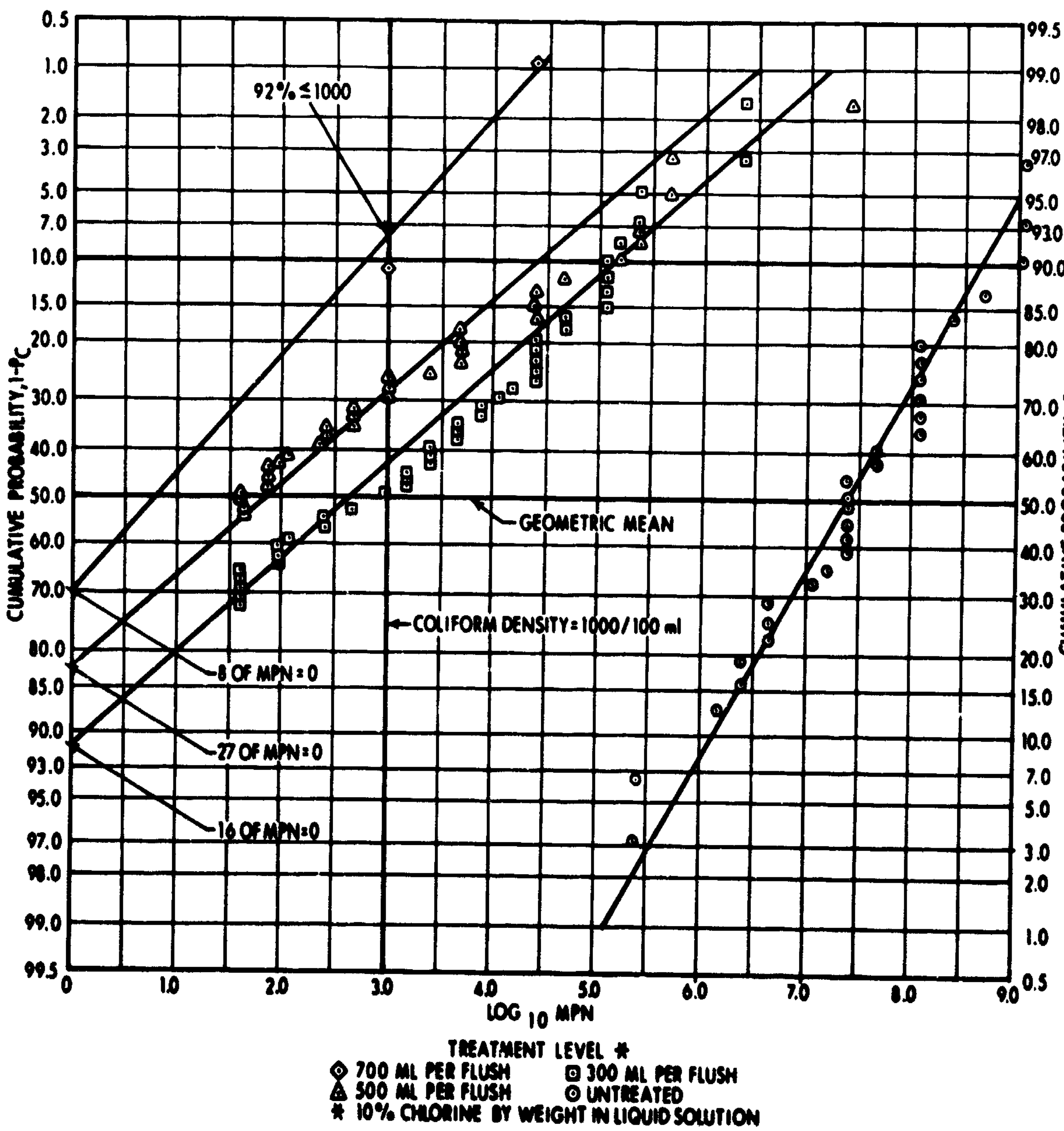
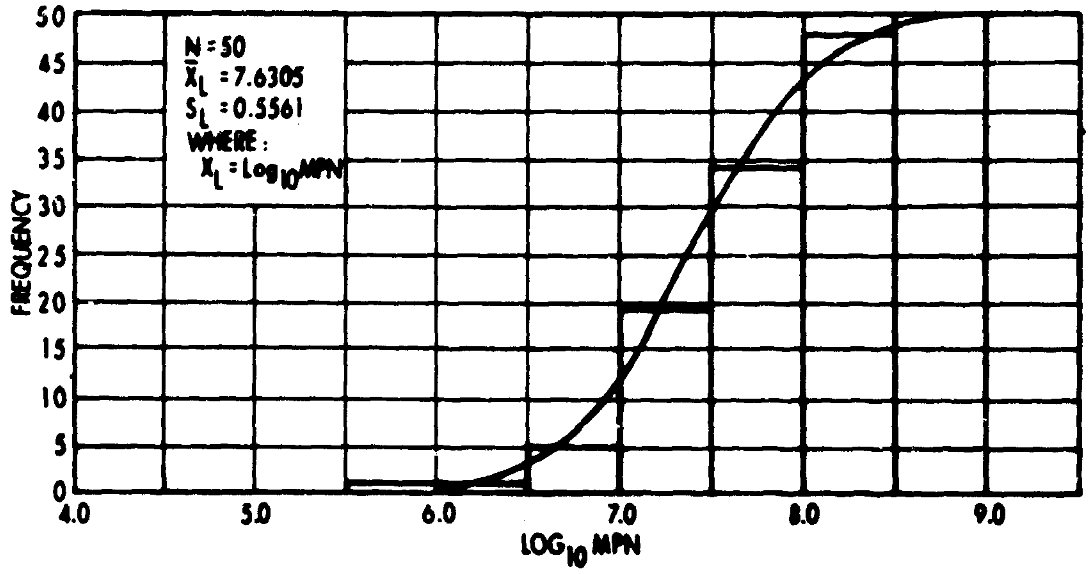


Figure 1 (Cont)

Item (a) - Machine A



Item (b) - Machine B

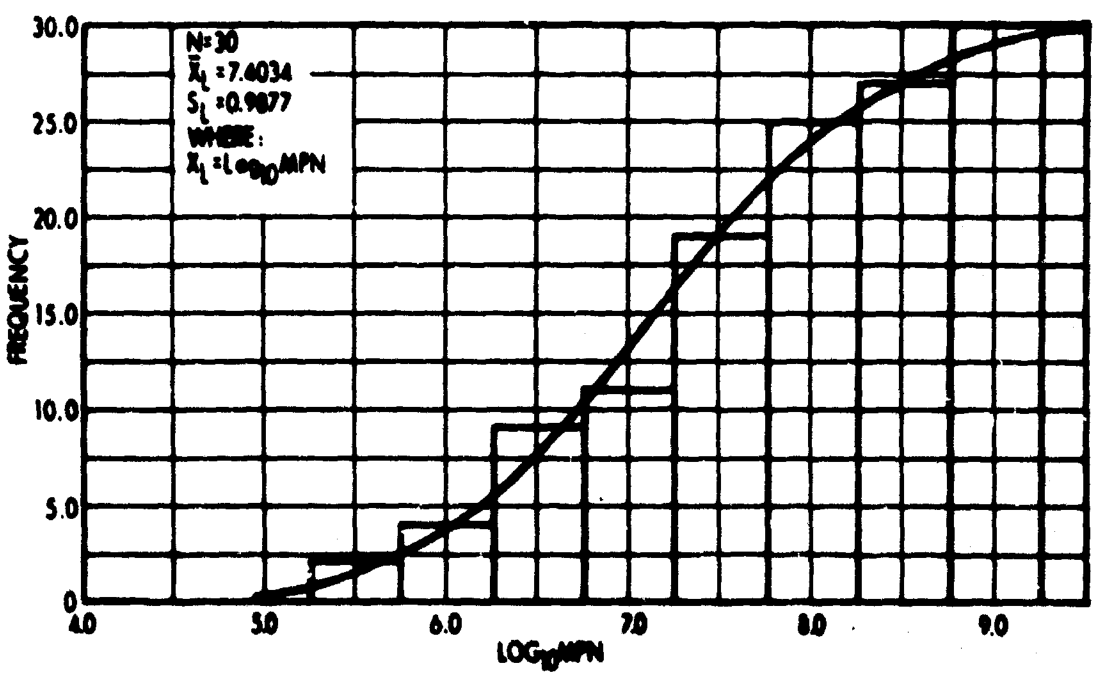
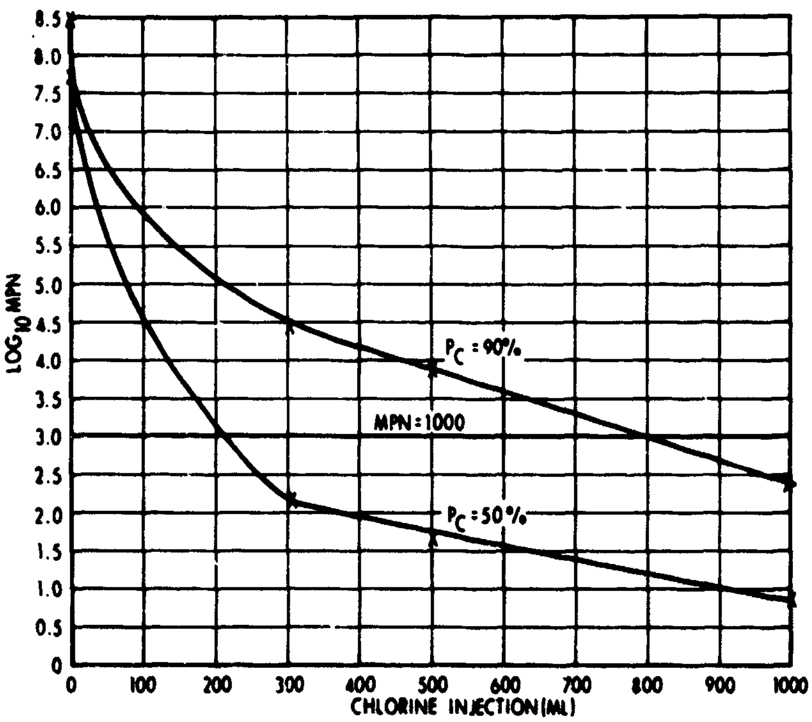


Figure 2 - Fitting, for Machines A and B, a Cumulative Lognormal Distribution Function to a Histogram of Coliform Counts (MPN) of Untreated Sewage Data

Item (a) - Machine A



Item (b) - Machine B

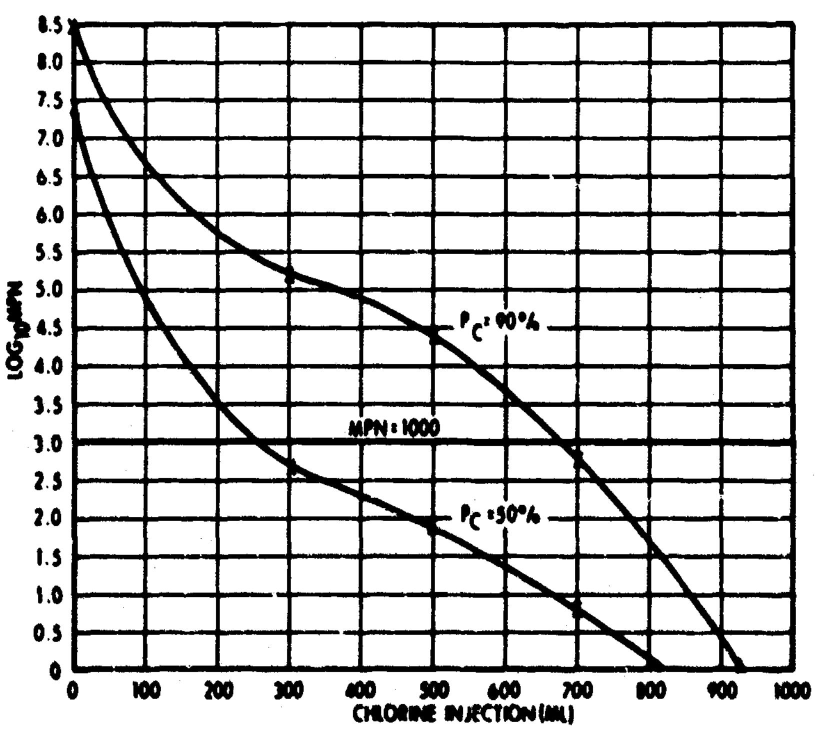


Figure 3 - Estimated Log_{10}MPN at the 50% and 90% Probability Levels for Chlorine Injection Treatment Curves

Item (a) - Machine A

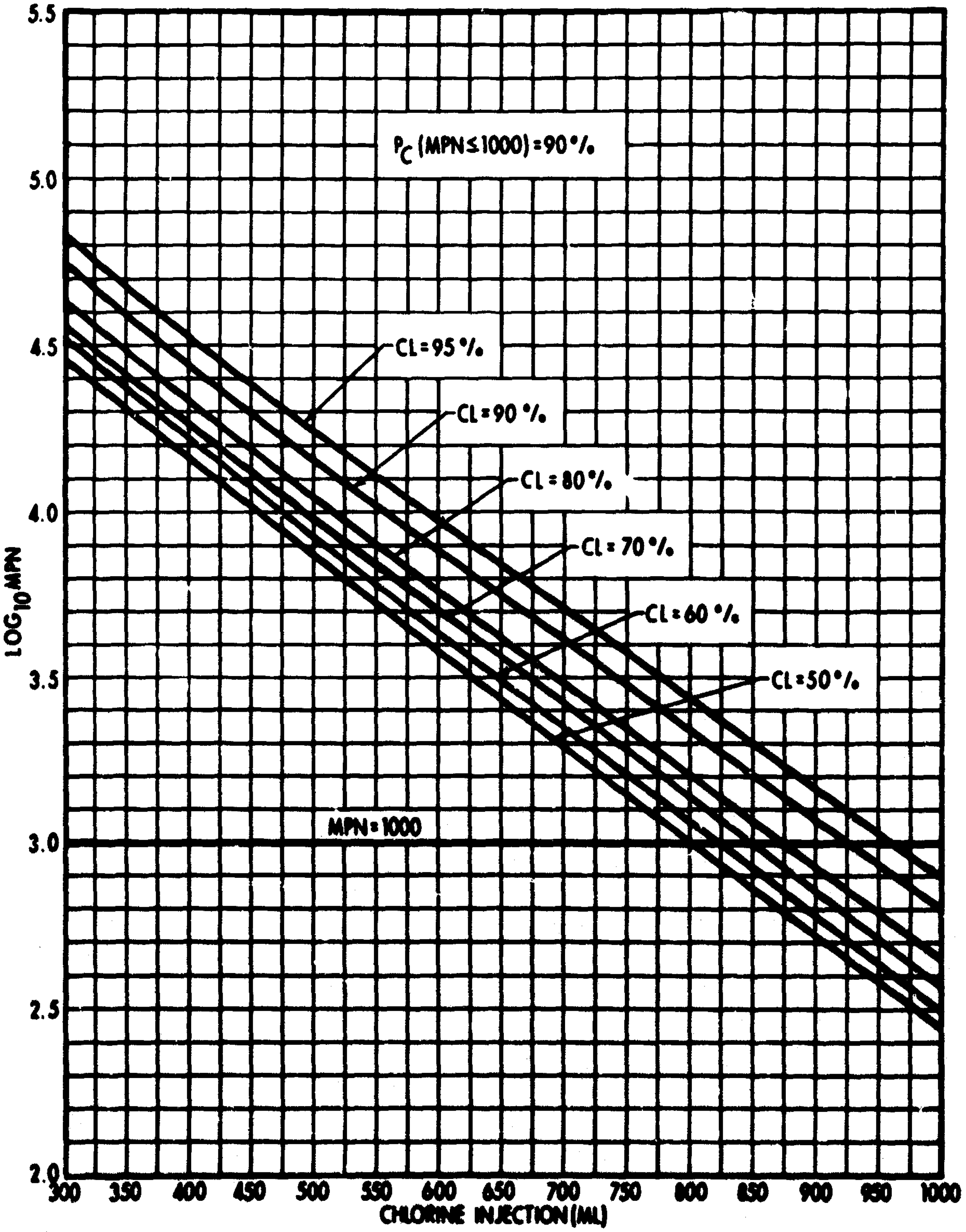


Figure 4 - Estimated Chlorination Injection (ml) Required to Show the Indicated Confidence (CL) That 90% of the Coliform Counts in a Particular Sample of Runs Will Have MPN ≤ 1000

Item (b) - Machine B

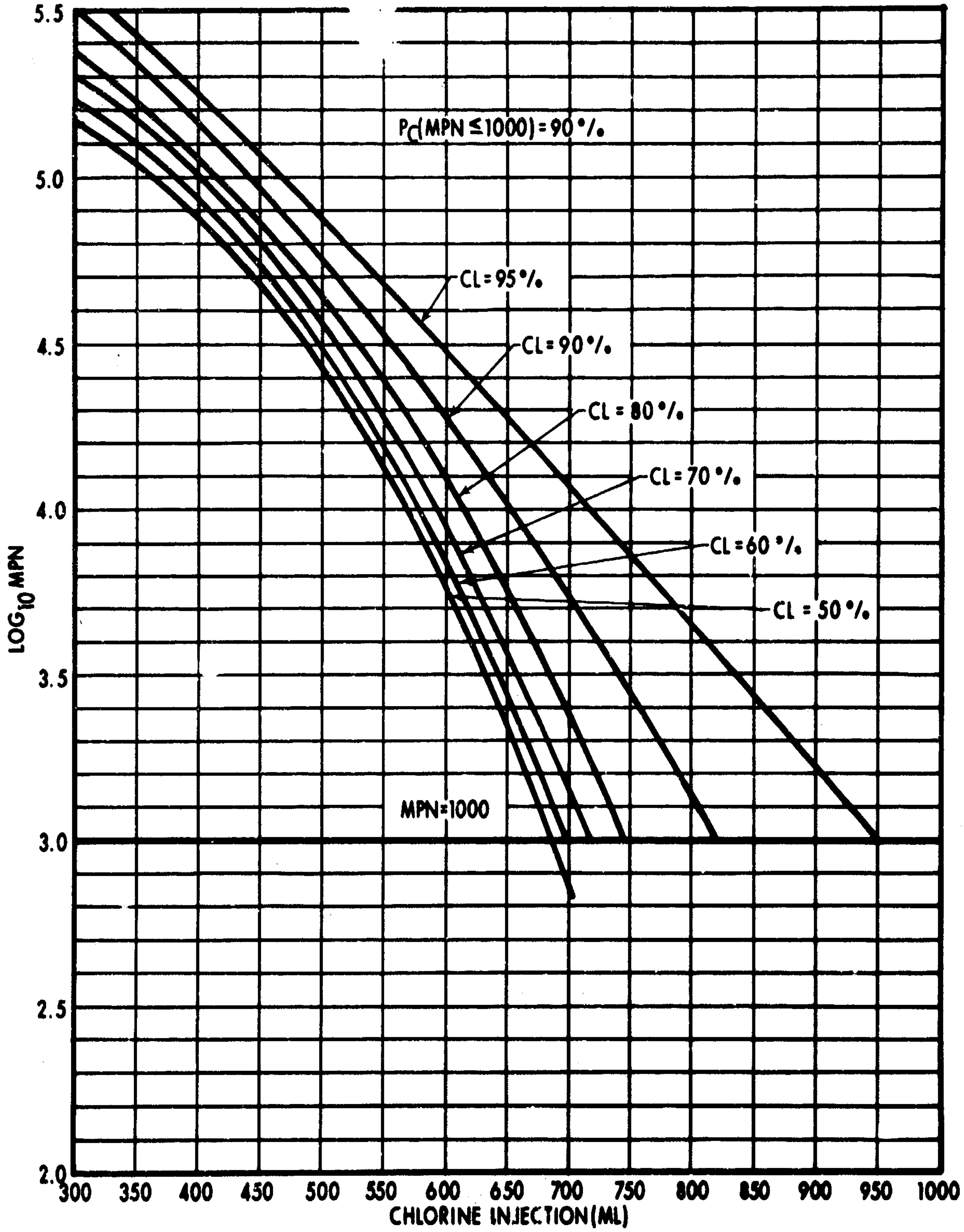


Figure 4 (Cont)

Appendix A

Plotting Lognormal Distribution Curves on Normal Probability Paper for Coliform (MPN) Density Counts

PLOTTING OF LOGNORMAL DISTRIBUTION DATA ON NORMAL PROBABILITY PAPER

1. List coliform MPN counts in ascending order of magnitude for a specific treatment condition (applied to a sample of N runs) and determine their corresponding $\log_{10}$MPN values (assume a nominal value of one for each tabulated zero MPN count, so that the corresponding $\log_{10}$MPN = 0).

2. Number each successive (ith) $\log_{10}$MPN value, i=1, 2, 3, 4, ..., N, and compute $P_i = (i/N+1) \times 100\%$.

3. Use an appropriate $\log_{10}$MPN scale (versus cumulative probability, P_i) such that all listed $\log_{10}$ MPN values for one or more samples of N runs (plotted on the same graph) will fall within the given $\log_{10}$MPN boundaries (e.g., Figure 1, where all $\log_{10}$MPN are between zero and 9.0).

4. Plot each tabulated ($\log_{10}$MPN, P_i) point for each sample of N runs, on normal probability paper. (Instead of plotting the zero MPN values, it might be convenient to simply indicate the number of zero MPN counts for each treatment. See Figure 1.)

PLOTTING OF LOGNORMAL DISTRIBUTION CURVES ON NORMAL PROBABILITY PAPER

1. Assume $X_L = \log_{10}$MPN for each coliform MPN count, for each sample of N runs (assume a nominal value of one for each zero MPN count, so that the corresponding $X_L = 0$).

Then, compute

$$X_L = \frac{\Sigma X}{N}$$

$$S_L = \left(\frac{N\Sigma X^2 - (\Sigma X)^2}{N(N-1)}\right)^{1/2} \quad ; \text{(Assume } X = X_L\text{)}$$

2. For each sample of N runs, select two of the computed plotting points ($\log_{10}$MPN, P_c) shown in the following table and draw a line through them such that $0 \le \log_{10}\text{MPN} \le$ some upper boundary (e.g., $\log_{10}\text{MPN} = 9.0$, as shown in Figure 1).

Plotting Points

$\log_{10}$MPN	P_c, %	$\log_{10}$MPN	P_c, %
$\bar{X}_L - 1.285s_L$	10	$\bar{X}_L + 0.253s_L$	60
$\bar{X}_L - 0.842s_L$	20	$\bar{X}_L + 0.524s_L$	70
$\bar{X}_L - 0.524s_L$	30	$\bar{X}_L + 0.842s_L$	80
$\bar{X}_L - 0.253s_L$	40	$\bar{X}_L + 1.285s_L$	90
$\bar{X}_L$	50		

It is customary to use the computed plotting points ($\bar{X}_L + 1.285s_L$, 90%) and ($\bar{X}_L - 1.285s_L$, 10%) if they exist within the given scale boundaries. Otherwise, select the closest highest and/or lowest computed probability points that do exist within the given boundaries. When the curves are drawn accurately, each should pass through the corresponding ($\bar{X}_L$, 50%) point, if it exists on the graph.

3. If the curves only are desired, it will not be necessary to list the sample MPN counts in order of magnitude. However, the $\log_{10}$MPN scale boundaries should be determined as before, based on the overall smallest and largest(inclusive) MPN counts for all the sample data curves to be shown on the same graph. Velz[1], and Kittrell and Firfari[2] plotted such curves by "eye."

[1] Velz, C. J., "Graphical Approach to Statistics, Part IV - Evaluation of Bacterial Density," Water and Sewage Works, 98, 1, 66, Jan 1951

[2] Kittrell, F. W., and S. A. Furfari, "Observation of Coliform Bacteria in Streams," Jour. Water Pollution Control Federation, Nov 1963

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Commanding Officer Naval Ship Research & Development Laboratory Annapolis, Maryland 21402	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Proposed Revision of Military Specification MIL-S-24201(SHIPS) Sewage Treatment Equipment Chlorinator-Macerator for Naval Shipboard Use

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Specification Development

5. AUTHOR(S) (First name, middle initial, last name)

Donald J. Fisk and Harold H. Singerman

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1969	24	1

8a. CONTRACT OR GRANT NO. b. PROJECT NO. Task Area S-F35 433 006 c. Task 1892 d. Assignment 823 121 32	9a. ORIGINATOR'S REPORT NUMBER(S) MATLAB 373 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Each transmittal of this document outside the agencies of the U.S. Government must have prior approval of Commanding Officer, Naval Ship Research & Development Laboratory, Annapolis, Maryland 21402

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	NAVSEC

13. ABSTRACT

A statistical evaluation of a variety of sewage treatment methods indicates that MIL-S-24201(SHIPS) should be revised with respect to performance requirements for the reduction of coliform most probable number density counts made after chlorination treatment of sanitary wastes. Such a proposed revision of the specification is given in this report which also indicates the coliform density for large samples of either untreated or treated sewage tends to follow a lognormal frequency distribution.

(Authors)

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

Unclassified

Security Classification

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Sewage treatment Chlorinators Macerators Coliform density Most probable number Performance Statistical analysis						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified

Security Classification